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INVESTIGATIONS OF THE ROTTING OF SLASH IN ARKANSAS.[1]

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CONTENTS.

	Page.		Page.
Introduction	1	The growth of wood-rotting fungi	9
Methods of brush disposal	2	Why brush in the center of the pile does not rot	10
White-oak slash	3	General discussion	11
Black-oak and post-oak slash	7	Summary	14
Shortleaf-pine slash	7		

INTRODUCTION.

Two very important factors must be considered in administering timber-sale areas, viz, the conservation of the present second growth and the leaving of the area in the best possible condition for future reproduction. The particular method of brush disposal over such areas is therefore of importance from the reproduction viewpoint. In the semiarid regions of the Southwest the dominant factor governing reproduction is the obtaining and conserving of sufficient moisture to germinate the seeds and to carry the seedlings over the first four or five years of their existence. In the forests of Arkansas the conservation of the moisture is of minor importance, since the annual rainfall is usually sufficient to supply all of the moisture necessary for the germination of the seed and for the continued growth of the seedlings.

Fire is a very important factor from a reproduction viewpoint in the National Forests of Arkansas. The Ozark National Forest consists almost exclusively of mixed stands of timber in which hard-

[1] The writer is under obligations to Mrs. Flora W. Patterson and Drs. E. A. Burt, C. L. Shear, and W. A. Murrill for assistance rendered in identifying many of the fungi mentioned in this bulletin.

wood trees usually predominate, while the Arkansas National Forest is dominated by pines. The annual leaf fall from the deciduous trees accumulating year after year on the ground and the large growth of underbrush present constitute a perpetual fire menace. Even on areas in these two forests where shortleaf pine (*Pinus echinata*)[1] is being logged there are usually enough deciduous trees and underbrush present to make a ground litter from the fallen leaves, to which must be added the usual leaf litter found under pine trees.

The method of brush disposal that will give to the reproduction over these areas protection from fire and yet leave as much as possible of the forest litter, leaves, twigs, etc., on the ground to rot, thereby adding fertility to the soil and protecting it against excessive erosion by restraining the run-off, is the one that should be adopted. The best method of brush disposal when the slash remains on logged areas is that which leaves the brush in such a condition that it will rot most rapidly, thus removing as soon as possible the fire menace from this source.

METHODS OF BRUSH DISPOSAL.

The three methods of brush disposal discussed in this bulletin are (1) pulling, (2) piling, and (3) scattering.

By "pulling" is meant that the brush in the tops of the felled trees is not lopped, but is left exactly as the tree tops fall except when they fall on or near reproduction. When brush is too close to reproduction it is pulled away from the young trees and merchantable timber, to decrease the danger from possible fire; hence the term "pulled brush."

The terms "piling" and "scattering" are self-explanatory.

Piling is the usual method of brush disposal followed in the National Forests of Arkansas. However, a few Forest Service areas were examined where the brush had been scattered as an experiment. In this State pulling the brush has not yet been practiced on Government sales, but on alienated or patented lands all of the brush in the tops of the felled trees is generally left as it falls. This is really a combination of "pulling" and "scattering," since the tops are left unlopped while the branches cut from the merchantable portion of the bole are scattered on the ground. The character and rate of rotting of the brush left on these private areas will therefore be the same as when the brush is pulled or scattered.

This bulletin deals specifically with the rapidity with which the brush rots and with the fungi causing this rotting under each of

[1] The nomenclature for trees used in this paper is that of George B. Sudworth. (Check list of the forest trees of the United States, their names and ranges. U. S. Dept. Agr., Div. Forestry Bul. 17, 144 p. 1898.)

these methods. It will be necessary in discussing the various methods of brush disposal to take into consideration the types of timber being cut. In the Ozark National Forest the main timber is white oak (*Quercus alba*) intermixed with black oak (*Q. velutina*), post oak, (*Q. stellata*), and several other species of minor importance, while on certain areas some shortleaf pine is found. In the Arkansas National Forest the bulk of the timber to be logged is shortleaf pine.

The investigations of the rotting of slash in Arkansas were carried on in the Arkansas and Ozark National Forests on areas which had been logged from 1 to 10 years. All of the areas examined which had been logged for more than five years were on private or patented lands, but located within these National Forests. The conclusions reached from these studies should be applicable to all of the other areas in these two forests, since the underlying principles are identical and the climatic conditions very similar.

WHITE-OAK SLASH.

FUNGI WHICH ROT THE SLASH.

Four main fungi were found rotting the white-oak slash, viz, *Stereum rameale*, *S. versiforme*, *S. umbrinum*, and *S. fasciatum*. All are sap-rotting fungi which cause but little apparent change in the texture of the wood. They produce what might be called indeterminate rots, since there are no well-defined characteristics which mark any one of them. All slightly discolor the wood, which later becomes whitish in color, lighter in weight, and easily broken. Strange to say, each of these fungi rots its own special portion of the slash. *Stereum rameale* is usually found attacking twigs which bear the leaves and very small branches (1 inch or less in diameter). This fungus seems to begin on the twigs and works gradually down them to where the branches are about 1 inch in diameter; there two other fungi (*S. versiforme* and *S. umbrinum*) take up the work and rot the small branches up to 2 or 3 inches in diameter, where a fourth fungus (*S. fasciatum*) usually begins its attack on the wood. This is the main fungus which rots the sapwood of the logs and large branches 3 inches or more in diameter, and it is often found rotting the sapwood of the stumps as well as the boles and large branches of standing dead oak trees. None of these fungi destroys the attacked wood completely, its final disintegration being left to other groups of fungi, insects, etc.

The heartwood of the large branches and trunks remains for many years after the sapwood is destroyed, but meantime it is being slowly rotted by a delignifying fungus (*Stereum frustulosum*), which produces small cavities or pockets in the wood.

Other fungi of minor importance were found attacking the oak slash, the most important of which was a small, dark-brown, gelat-

inous fungus (*Exidia glandulosa*) found at irregular intervals along the twigs and small branches. Its action on the wood is to produce whitish rotten areas, usually extending entirely through the branch, thus forming a line of weakness which ultimately causes the branch to break into small sections (2 to several inches long). These pieces fall to the ground, where complete disintegration follows.

Merulius corium, *Hymenochaete curtisii*, *Diatrype stigma*, and *Stereum hirsutum* are other fungi occasionally found attacking the twigs and small branches, while *Merulius tremellosus*, *Polystictus pergamenus*, *P. versicolor*, *Polyporus gilvus*, *P. cinnabarinus*, *P. benzoinus*, *Lenzites betulina*, *Flammula* sp., *Panus stipticus*, *Stereum spadiceum*, *Lycoperdon pyriforme*, *Xylaria hypoxylon*, and several species of Poria are occasionally found rotting logs, stumps, and large branches.

Panus stipticus, *Flammula* sp., *Merulius tremellosus*, *Xylaria hypoxylon*, and *Lycoperdon pyriforme* are fungi which apparently attack wood which has been more or less rotted by other fungi.

Polystictus pergamenus, *P. versicolor*, *Polyporus gilvus*, *P. cinnabarinus*, *P. benzoinus*, and *Lenzites betulina* rot both the sapwood and heartwood, but unfortunately none of them are common on oak slash in the forests of Arkansas. None of the fungi found rotting the oak slash produces a heart rot in the living tree. However, certain fungi which cause heart rots in living oak trees will continue to grow in the infected wood after the trees are felled. The most important of these are *Hydnum erinaceus*, *Polyporus pilotae*, *P. sulphureus*, and *Stereum subpileatum*.

BRUSH WHEN PULLED.

Soon after a living tree is felled, wood-boring insects and various fungi begin their work of disintegration and decay. The first evidence of fungous activity in slash is a discoloration of the sapwood in the twigs, branches, and trunks, which usually begins a few months after the trees are felled. Marked evidences of decay in the shape of well-defined rotten spots and areas in the wood and the formation of fruiting bodies or sporophores of the wood-rotting fungi do not appear until one or two years after the trees are felled.

All of the leaves in the tops of felled oak trees will usually fall in from one to three years, depending more or less upon the age of the leaves at the time the oak was cut and to a slight extent on the locality in which the timber is situated.

The small branches and twigs gradually rot, and the majority of them will have fallen to the ground at the end of four years. By the end of six years practically all of the branches in the tops will have rotted and fallen except some of the very large ones which have much heartwood. Also, practically all of the sapwood in the boles and cull logs will have rotted away during this time.

BRUSH WHEN PILED.

White-oak brush piles were examined, ranging from 1 to 5 years in age. During the first year after the trees were cut but little evidence of rot could be seen except a discoloration of the sapwood. By the end of the second or third year all of the leaves had fallen from the twigs which were exposed to the sun's rays, and the brush at the tops and sides of the piles where exposed to the sunlight had rotted to some extent, while the slash in the middle of the piles not in actual contact with the ground and yet protected from the sunlight was rotted but slightly, if at all. The twigs and small branches at the bottoms of the piles were more or less rotted by certain other fungi (called "ground" fungi in this bulletin), which apparently entered these branches from the soil. These ground fungi seem to rot the brush more rapidly and more thoroughly than the regular slash-rotting fungi.

Usually there is but little evidence of rot in the center of the piles during the first four years after piling. However, around the edges and through crevices in the top the sunlight sometimes penetrates sufficiently to permit slight fungous growth. Nevertheless, there is a marked difference between the rotting of the brush in the center of the piles not adjacent to the ground and that at the top and bottom of the pile.

By the end of five years the top and bottom of the piles have rotted to a considerable extent, while the brush in the center of the piles, where it had become more or less exposed to the sun's rays, was beginning to rot.

For the brush in the center of the piles to rot completely it apparently (1) must be brought within range of the soil moisture by the rotting of the brush below it and by the settling of the pile, or (2) the upper portion must disintegrate sufficiently for the sun's rays to reach the center of the pile. Undoubtedly, both conditions finally develop and aid in the rotting of the brush which was originally in the center of the piles.

In a white-oak brush pile the layer of brush at the bottom would be the only one even in partial contact with the soil, while the remainder of the pile would be held from the soil by this first layer and therefore could not receive any benefit from the soil moisture. Neither are the piles dense or compact enough to raise the moisture content of the air around the brush in the piles sufficiently to encourage the growth of the ground fungi in branches not in actual contact with the soil. On the other hand, the brush not in contact with the soil in the piles and yet sheltered from sunlight is deprived of the activity of the fungi which normally rot slash in the open; that is, slash when left as it falls in the tree tops.

Since piles more than five years old were not found, the writer can not state positively the length of time necessary for a medium-sized compact brush pile of white oak to rot completely. Apparently it would take from three to six years longer than if the brush were either pulled or scattered. However, if the piles are very small, the brush will rot with about the same rapidity as when the tops are left unlopped, since the sunlight can then penetrate to the bottom.

SPOROPHORE DEVELOPMENT ON PILED BRUSH.

The difference between the development of sporophores at the top, middle, and bottom of brush piles is very marked. Practically every twig and limb at the top of the pile bore the characteristic sporophores of *Stereum rameale*, *S. umbrinum*, and *S. versiforme* on the rotting limbs, while no sporophores whatever were found on branches in the center of brush piles which were large and compact enough to exclude the sunlight. Very rarely were any sporophores of wood-rotting fungi found on the material at the bottom of the piles, although sterile mycelium was frequently present on the brush so situated. It was therefore difficult to determine what fungi were concerned in the rotting of the brush in the bottom of the piles. However, sporophores were found of *Merulius tremellosus*, *Peniphora flavido-alba*, *Odontia* sp., *Poria pulchella*, and two unidentified species of Poria.

BRUSH WHEN SCATTERED.

When the brush is lopped and scattered it rots much more quickly than when piled, and in some localities somewhat more quickly than when left attached to the tops. On the areas examined the gain in the rotting of brush when scattered compared to that when pulled was usually about one year.

When white-oak brush is scattered, only small portions of the limbs are actually in contact with the soil. The same fungi, therefore, that rot the unlopped brush will also rot most of the scattered brush, and with about the same rapidity.

Brush lying on the ground sometimes absorbs from the soil sufficient moisture for the growth of ground fungi in those portions of the limbs which are in actual contact with the soil. On many of the areas examined the additional moisture obtained from the soil by the scattered brush was not sufficient to cause the ground fungi to attack the prostrate limbs.

The influence of soil moisture on the branches lying on the ground usually does not extend more than 4 to 6 inches from the point where the limb is in contact with the soil. This means that the benefit to be derived from the ground fungi rotting a branch is limited to that portion directly in contact with the soil. On account of the small quan-

tity of the brush thus situated, little of it is attacked by the ground fungi, and the benefits thereby derived are correspondingly slight.

At the end of five to six years all of the brush (twigs and small branches) which was scattered will have rotted, and much of it will have disappeared. It was also no uncommon thing to find partially rotted brush, whether piled, scattered, or lopped, attacked by white ants (termites) and the partially rotted wood replaced to some extent by dirt.

BLACK-OAK AND POST-OAK SLASH.

Black-oak and post-oak slash was attacked by practically the same fungi which rot the white oak; however, but little of this type of slash was seen. The twigs and small branches of the black oak in most of the cases examined seemed to rot somewhat more slowly than white-oak slash of the same character, while the post-oak slash seemed to rot with about the same rapidity as the white oak.

Polyporus cinnabarinus was occasionally found rotting the large limbs and boles of the black oak, while the small twigs and limbs of the post-oak slash were sometimes attacked by *Schizophyllum commune*, and cull logs and stumps were occasionally attacked by *Lentinus lecomtei*. *Stereum ochraceo-flavum* was the principal fungus found rotting fire-killed oak bushes 2 inches or less in diameter, while *Polystictus pergamenus* was the fungus usually found attacking fire-killed trees and fire-killed areas on standing living trees of all species of oak.

SHORTLEAF-PINE SLASH.

Shortleaf-pine slash was examined on areas which had been logged from two to nine years.

FUNGI WHICH ROT THE SLASH.

Two main fungi were found rotting the shortleaf-pine slash. One begins work in the ends of the small branches and works downward toward the trunk. This is usually *Lenzites sepiaria*, a dry-rot organism prevalent throughout the United States. This fungus has never been found by the writer attacking slash which was not exposed to the direct rays of the sun.

The second fungus enters the cull logs, boles of the tree tops, and branches 2 inches or more in diameter. It is what the writer previously has called the "white-fir fungus" (*Polystictus abietinus*).[1] It is a sap-rotting organism and usually rots but little, if any, of the heartwood.

[1] Long, W. H. A new aspect of brush disposal in Arizona and New Mexico. *In* Proc. Soc. Amer. Foresters, v. 10, no. 4, p. 383–398. 1915.

At the bottom of brush piles a fungus which has been identified as *Polyporus amorphus* was rather common. It apparently does not attack branches and limbs which are not in contact with the soil.

Merulius ambiguus was occasionally found on small branches, while *Fomes annosus*, *Poria subacida*, and *P. vaporaria* were found on large prostrate limbs, trunks, and stumps. *Polyporus palustris*, *Fomes annosus*, and *Corticium galactinum* seem to be the principal fungi rotting the pine stumps.

BRUSH WHEN PULLED.

All of the needles in the tops of felled shortleaf-pine trees will fall in from one to three years, depending somewhat on the locality in which the timber is located. The branches will gradually rot, and many of them will have fallen from the trunk at the end of three to four years. By the end of five years practically all of the branches, large and small, in the tops will have rotted and fallen to the ground. Also, most of the sapwood in the boles and cull logs will have rotted in this time.

Pitchy limbs and trunks containing much resin rot very slowly and may be found long after the less resinous wood has disappeared.

Polystictus abietinus and *Lenzites sepiaria* seem to rot branches which are 8 to 10 feet from the ground just as rapidly as those near the ground. *Lenzites sepiaria* also attacks decorticated logs and the exposed portions of railroad ties after they are laid in the track.

BRUSH WHEN PILED.

Shortleaf-pine brush piles were examined, ranging from 1 to 5 years in age. It was found that during the first year after the tree was cut but little rotting occurred, even in the small branches. By the end of the second or third year practically all of the needles had fallen from the limbs which were exposed to the sun's rays, while the needles in the middle of the piles, which were protected by the overlying brush, were in good condition and still attached to the limbs. In five years, brush at the top of the piles had practically rotted as far as the fungi which were attacking them could rot it, while the brush in the middle of the piles showed few signs, if any, of rotting. In the bottom of the piles the brush was well rotted, but by fungi different from those rotting the brush at the top of the piles. In other words, a brush pile of shortleaf pine will be rotted at the top by *Lenzites sepiaria* and *Polystictus abietinus*, the center of the pile will be rotted but little, while the brush at the bottom of the pile in contact with the soil will be rotted by certain ground fungi, one of which has been identified as *Polyporus amorphus*. This means that before the center of the brush piles will rot, both the top and

bottom of the piles must disintegrate sufficiently to expose the center of the pile either to the sunlight or to the moisture of the soil. This would probably add from three to five years at least to the length of time it would take to rot the slash in the brush pile as compared to that required if pulled or scattered.

BRUSH WHEN SCATTERED.

Practically the same conditions hold for shortleaf-pine slash when lopped and scattered as for oak slash; that is, the same groups of fungi which attack the pulled pine slash will attack the slash when scattered on the ground unless it be covered with leaf débris. Ground fungi will also attack that portion of the brush immediately in contact with the soil, provided the area under consideration is not too dry, like the south and southeast slopes of steep hillsides. In such locations no evidence was found of ground fungi attacking the scattered brush, or even the brush in the bottom of the piles. This means that the pine brush when lopped and scattered will rot much quicker than when it is piled, and on some sites slightly quicker than when left attached to the tops or pulled.

THE GROWTH OF WOOD-ROTTING FUNGI.

There is this physical factor to be kept in mind when considering the rotting of slash, viz, that the quantity of water which a limb or branch obtains is practically limited to the precipitation which that limb or branch receives and is able to absorb through its bark into the sapwood and that, so far as the amount of moisture in the wood itself is concerned, the humidity of the air around the branch would not be an important factor, since conditions would have to be very unique which would enable a branch covered with bark to absorb from the surrounding air a sufficient quantity of water to make any appreciable difference in the water content of the branch or limb. This would mean that the distance the branch was from the ground, whether 1 foot or 5 feet, would make but little difference in the relative supply of moisture obtainable from the atmosphere which the wood-rotting fungi in the branch could utilize. It might, however, determine to a slight extent the amount of moisture which the limbs could lose, especially in the bottoms of the piles. In regions of heavy dews the brush lying within 1 or 2 feet of the ground might obtain more moisture than brush farther from the ground.

This indicates that the slash would have to be practically in contact with the soil to gain any appreciable quantity of moisture other than that obtained from precipitation, and from the very nature of the oak brush only small portions of any given limb would be thus placed.

Different groups of fungi seem to have adapted themselves to certain growth conditions. For instance, *Stereum rameale* and *S. hirsutum* were usually found only on the twigs and small branches, while *S. umbrinum* and *S. versiforme* occurred mainly on twigs and branches 2 inches or less in diameter. None of these four fungi were found attacking large limbs and trunks of the felled trees, while *S. fasciatum*, very common on stumps and trunks, rarely occurred on branches less than 3 inches in diameter. None of them were found growing on timber which was entirely shaded from the sun.

The fungi which rot that portion of the branches lying in actual contact with the ground under the brush piles belong to an entirely different group. Such fungi apparently need a large supply of moisture and probably enter the wood from mycelia already growing and ramifying in the leaf débris in the soil. This group of fungi includes those which are normally found attacking wood partially or entirely buried in the soil, such as stumps and posts.

WHY BRUSH IN THE CENTER OF THE PILE DOES NOT ROT.

Why the fungi which are found attacking the limbs exposed to the sunlight will not usually attack the brush in the center or bottom of the piles when protected from the sun's rays is not known. Apparently temperature and moisture are not the only prominent factors controlling fungous growth and activity in nature. Is it possible that sunlight is a factor in the germination and growth of wood-rotting fungi in their natural habitats?

In a previous article by the writer,[1] the theory was advanced that the reason why the brush in the center and bottoms of the piles in the semiarid regions of Arizona and New Mexico did not rot was due to temperature conditions prevailing in the high altitudes. That the temperature in Arkansas could be a prominent factor in the rotting of the brush, or, rather, in the lack of the rotting of the brush in the middle of the piles, seems hardly possible, since the temperature there is sufficiently high during a large portion of the year for fungous mycelia to grow vigorously, provided the other factors necessary for fungous growth are also present.

The precipitation in Arkansas is sufficient to supply all the moisture necessary throughout the entire brush pile for the active growth of wood-rotting fungi. It seems, therefore, that enough moisture would persist in the center of the piles for the brush to rot at least as rapidly as the pulled brush. The fact that twigs and branches in the center of piles large enough to be shaded from the rays of the sun were the only ones not rotted seems to indicate that sunlight may possibly play a part in the rotting of the brush, not only in Arkansas,

[1] Long, W. H. Op. cit., p. 395–396.

but also in Arizona and New Mexico, where the same conditions as to the rotting of the limbs in the center of the piles were found to exist.[1]

It is very evident that certain groups of fungi capable of rotting the small twigs and branches of trees which have died in the forest or of trees which have been felled are not capable of thriving under the conditions found in the center of large and compact brush piles. This is further accentuated by the fact that the bottoms of the brush piles in Arkansas, when rotted at all, are not rotted by these fungi, but are attacked by other fungi, such as *Fomes annosus*, which are known to live in more or less shaded and underground habitats.

What the factors are that dominate the growth and activity of these various groups of fungi is not known. For instance, why is it that usually *Stereum rameale* and *S. hirsutum* rarely attack limbs above 1 inch in diameter, while *S. umbrinum* and *S. versiforme* are rarely found in limbs larger than 2 or 3 inches in diameter? Why do not these fungi usually attack logs and large branches? Is the moisture content too high or the temperature too low? On the other hand, *Stereum fasciatum*, the common fungus rotting the cull logs and boles of the oak slash, usually does not attack the twigs and small branches. Of course, the explanation for this fungus might be that the twigs and small branches have not a sufficient amount of moisture, but such an explanation could not be offered for the failure of *Stereum rameale*, *S. versiforme*, and *S. umbrinum* to attack the large branches and trunks.

It would seem that but little is known concerning the real factors controlling fungous activity in wood. It is evident, however, that certain groups of fungi are capable of rotting the wood as it is normally found in nature; that is, when a tree dies, is killed by lightning, or is wind thrown. These are conditions which have been occurring in nature through centuries, and certain fungi have adapted themselves to such conditions. The same could be said of limbs and logs which are in contact with the soil, or even buried in the soil, since such conditions are normal and found generally in nature.

Apparently there are no fungi capable of vigorous growth under the artificial environments found in the center of large brush piles, where the conditions do not approximate those existing either when the brush is in contact with the soil or when it is exposed to the sunlight.

GENERAL DISCUSSION.

Several factors, such as fire, reproduction, and the rotting of the brush, are so intimately associated that it is impossible to discuss any one phase of brush disposal without noting, at least briefly, the

[1] Long, W. H. Op. cit., p. 389–390.

possible influence of these other factors. It is obviously impossible to arrive at any legitimate conclusion concerning the best method of brush disposal by limiting the discussion to the pathological side of the question as seen in the rotting of the brush itself. The fire hazard, as it seems to exist in Arkansas, is therefore briefly discussed in connection with brush disposal from the pathological viewpoint.

In the Arkansas National Forest about 3 to 5 white-oak trees are felled to the acre, and about 5 to 10 pine trees to the acre. In the Ozark National Forest the proportion of white-oak trees felled is somewhat greater, running probably from 5 to 10 trees to the acre, while there is but very little pine cut on this forest. This means that on any area in either of these two National Forests where timber is being cut, especially white oak, a much greater percentage of standing trees of all sizes, including those below the merchantable diameter limit, is left than is cut. This standing timber will add its annual quota of fallen leaves to the ground cover, irrespective of what method of brush disposal is followed. The amount of litter in the shape of slash, on account of the small number of trees cut per acre, in many cases will not make fires more likely to start or prevent their control, since there will always be a sufficient quantity of leaf litter and underbrush present to make a good ground fire, even if there be no slash on the ground. If the deciduous trees are cut with the leaves on them the amount of leaf litter will not be increased, since these leaves would fall to the ground in the autumn even if the trees were not cut; in fact, there would really be less leaf litter on the ground, because the leaves persist on the felled tree tops and branches from one to three years.

There is also this fact to be borne in mind, that oak trees cut from November to March, inclusive, are leafless or practically so, and the brush from them will not materially increase the fire hazard unless it is piled.

In 1912 and 1913 the writer visited areas in the Ozark National Forest which were then being logged. In the studies made in 1915, only two to three years later, many of these areas had been burned over. It can probably be said truthfully that the greater portion of the Ozark National Forest, except about 100,000 acres in the middle of the central division, will be burned over at least once within a period of five years, and often within a much shorter interval. It seems, therefore, that whatever system of brush disposal is followed in this forest should take into consideration the certainty of fire as well as the rotting of the brush.

In the Arkansas National Forest many areas are not burned over more than once in every 20 years. Under such conditions the rotting of the brush is the main factor to be considered.

No areas were seen on which brush had been cut and scattered where there had been fire. What effect, therefore, a fire would have on such areas as compared with those on which brush had been piled or pulled can not be stated from actual observation. However, areas were seen on which there had been fires where brush had either been pulled or piled. Many trees whose tops had been left with the limbs unlopped were seen with the needles or leaves burned from only the lower half of the tops. This leaving unburned the leaves and needles in the upper half of the felled tree tops seemed to indicate that fires in the forests of Arkansas in pulled brush do but little, if any, more damage than the regular ground fire which is fed by the normal annual leaf débris and underbrush. Many areas on which the brush had been piled were seen where forest fires had killed a large portion of the young reproduction up to 4 inches in diameter.

Brush when lopped and piled rots much more slowly than under either of the other methods of disposal. Such piles may be expected to persist from three to six years longer than the same brush when pulled or scattered, depending upon the size and compactness of the piles. This would eliminate the large brush piles from consideration in disposing of the slash on these areas.

The best method of brush disposal over such areas would be that which is the least expensive, which reduces to a minimum the damage to the forest when fires occur, and which leaves the slash in such condition that it will rot most rapidly. It is very evident in view of these three things that the lopping and piling of the brush is the poorest method to follow, since not only is it the most expensive, but brush when piled rots the slowest and the reproduction on such areas is apparently damaged most by forest fires, judging from the burned areas seen. This would leave the choice between scattering and pulling.

Pulling, as practiced in coniferous timber, would not be practicable in certain types of hardwood sales, such as stave sales, since the oak tops are usually too heavy to be moved as a whole by the methods of logging in use on such areas. However, when tree tops fall near reproduction or near trees to be left, it is immaterial whether the top is pulled away by a team or by hand or whether the objectionable sections of the top are sawed out and rolled away.

Brush when pulled or left in the tops rots with nearly the same rapidity as when lopped and scattered. The difference in time between the rotting of the pulled and of the scattered brush is apparently about one year in favor of the scattered brush. Whether a possible maximum gain of one year in the time of rotting between the brush that is pulled and that which is scattered is sufficient to offset the difference in cost between these two methods must, of course, be considered.

SUMMARY.

(1) When the brush is lopped and scattered it rots more rapidly than when either piled or pulled. This is due to the fact that two types of fungi rot the brush, one entering the limbs and branches not in direct contact with the ground and the other entering those portions of the brush in actual contact with the soil.

(2) The maximum gain in the rapidity of the rotting of the brush when scattered over the same brush when left unlopped in the tree tops is about one year. On dry areas, such as steep hillsides with southern and western exposures, there is practically no difference in the rate of rotting of the brush when scattered and when the tree tops are left unlopped.

(3) Brush when lopped and piled will apparently take from three to six years longer to rot than when scattered or when left unlopped.

(4) Brush when piled is rotted at the top by one group of fungi and at the bottom by another group, while the middle of the pile, not in contact with the soil and yet protected from the sunlight, apparently will not rot to any extent until the pile disintegrates sufficiently to expose these central layers to the soil moisture on the one hand or to the sunlight on the other.

(5) The same general facts as to the rotting of the slash hold for all species of timber (pine, oak, etc.) examined in Arkansas.

(6) Four fungi are the main agents in the rotting of oak slash in Arkansas, viz, *Stereum rameale*, *S. umbrinum*, *S. versiforme*, and *S. fasciatum*.

(7) Two main fungi rot the shortleaf-pine slash, viz, *Polystictus abietinus* and *Lenzites sepiaria*.

(8) No definite conclusions could be reached concerning the principal fungi which rot the bottom of the piles, since but few sporophores of such fungi were found.

(9) None of the main fungi concerned in rotting either the oak or the pine slash in Arkansas produce heart rots in living trees.

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